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In modern U.S. agriculture there are numerous tradeoffs between agricultural and chemical policies. Chemicals are major inputs in agricultural production processes (for both crops and livestock). Agricultural chemicals, however, have negative environmental side effects that are not always considered by users (Benbrook 1988). Agricultural policies primarily are designed to stabilize commodity prices and enhance farm income, which in turn changes production levels, provides incentives for different intensities of factor use, and influences the loading of chemicals. In turn, chemical policies involving taxes, use restrictions, and registration requirements change the availability and prices of chemical inputs, alter agricultural production and cost levels, and affect agricultural income.

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Trade-Offs between Agricultural and Chemical Policy

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Abstract

In modern U.S. agriculture, there are numerous trade-offs between agricultural and chemical policies. This study provides an empirical context for general observations of trade-offs between commodity policies designed to stabilize income and chemical policies that affect the availability and prices of chemical inputs. Four examples of policies involving trade-offs between agricultural and chemical policies are reviewed. These illustrate conservation compliance, taxation of commercial nitrogen, targeting of conservation reserve enrollment, and banning of corn rootworm insecticides.

Generally, these analyses showed that environmentally motivated changes in agricultural production patterns and practices could be accommodated in U.S. agriculture with relatively modest increases in production costs. Results indicate considerable opportunity for bringing agricultural price and income stabilization policy mechanisms into closer harmony with environmental policy. Clearly, outcomes from linked policies are highly conditioned by the market supply/demand situation as well as the agricultural policy framework. The argument, then, is for flexible policies and a recognition that settings of policy instruments for policymakers will require adjustment as the factors conditioning agriculture and the environment change.

Introduction

Modern U.S. agriculture entails numerous trade-offs between agricultural and chemical policy. Chemicals are major inputs in agricultural production processes for both crops and livestock; however, their negative environmental side affects are not entirely accounted for in private-sector usage decisions (Benbrook 1988). Agricultural policies are primarily designed to stabilize commodity prices and enhance farm income, which in turn change production levels, provide incentives for different intensities of factor use, and influence the loading of chemicals. In turn, chemical policies--e.g., taxes, use restrictions, and registration--by changing the availability and prices of chemical inputs, alter agricultural production and cost levels and affect agricultural income.

The purpose of this paper is to provide an empirical context for these very general observations on trade-offs. To do so, the dimensions of the discussion are narrowed. First, for agricultural policy, the review is limited to crops and, more particularly, to commodity policy derived from farm bill legislation. Chemical policies investigated will relate to authorities of the Environmental Protection Agency (EPA), to regulations emerging in states, and to supply control provisions of farm bill legislation. Four examples are used for illustration: conservation compliance, taxation of commercial nitrogen, targeting of conservation reserve enrollments, and banning of corn rootworm insecticides.

In the discussion to follow, the issue of trade-offs between agricultural and chemical policies is first discussed relative to the current agricultural supply and demand situation. One observation that emerges involves the opportunity for win-win situations in regulation when agricultural policies incorporate supply control measures. Also, the linking of agricultural and chemical policy can force or encourage certain forms of trade-offs. But, the outcomes for these tied provisions are highly dependent on the commodity supply-demand situation, the availability of alternative production technologies, and the restrictiveness of the supply control provisions. Next, the four examples of policies involving trade-offs between agricultural and chemical policies are reviewed. Generally, the empirical findings are from research by the Center for Agricultural and Rural Development (CARD). And, they involve comparisons between a baseline and selected policy options. Last, some general observations are drawn on orders of magnitudes of the trade-offs between agricultural and chemical policy.

Trade-Off Opportunities

Ideas for exploiting opportunities for trade-offs between agricultural and chemical policy received increased attention in the debate leading to the Food Security Act of 1985 (FSA85). In the FSA85, broad environmental provisions were for the first time tied to agricultural commodity titles (Glaser 1986). The agricultural situation during the FSA85 debate was one of high excess productive capacity at government-supported prices, high stocks relative to historical stocks/use ratios, and the necessity to idle significant productive resources to control government cost and stocks. In this type of setting, agricultural and environmental win-win policy possibilities do exist (Dvoskin 1988). First, a reduction of government intervention in the commodity markets could be achieved. It has been argued that if all farm support programs were eliminated, the resulting crop mix--though expanded in acreage--would be more beneficial to the environment (Phipps and Reichelderfer 1989). Second, the excess supply could be reduced, providing gains for program costs and the environment without significant changes in prices and government cost.

Environmental measures enacted as part of FSA85 included the conservation reserve, conservation compliance, the swamp buster, and other provisions that achieved increased environmental quality while not significantly altering farm income and government costs of operating the farm program. Commodity policy changes consisted of a gradual lowering of supported prices and a freezing of base acres and yields on which subsidies are paid. Of course, the EPA has influenced environmental and agricultural trade-offs by registering or deregistering a number of agricultural chemicals. In many cases, substitutes for these chemicals have been available at only slightly higher costs.

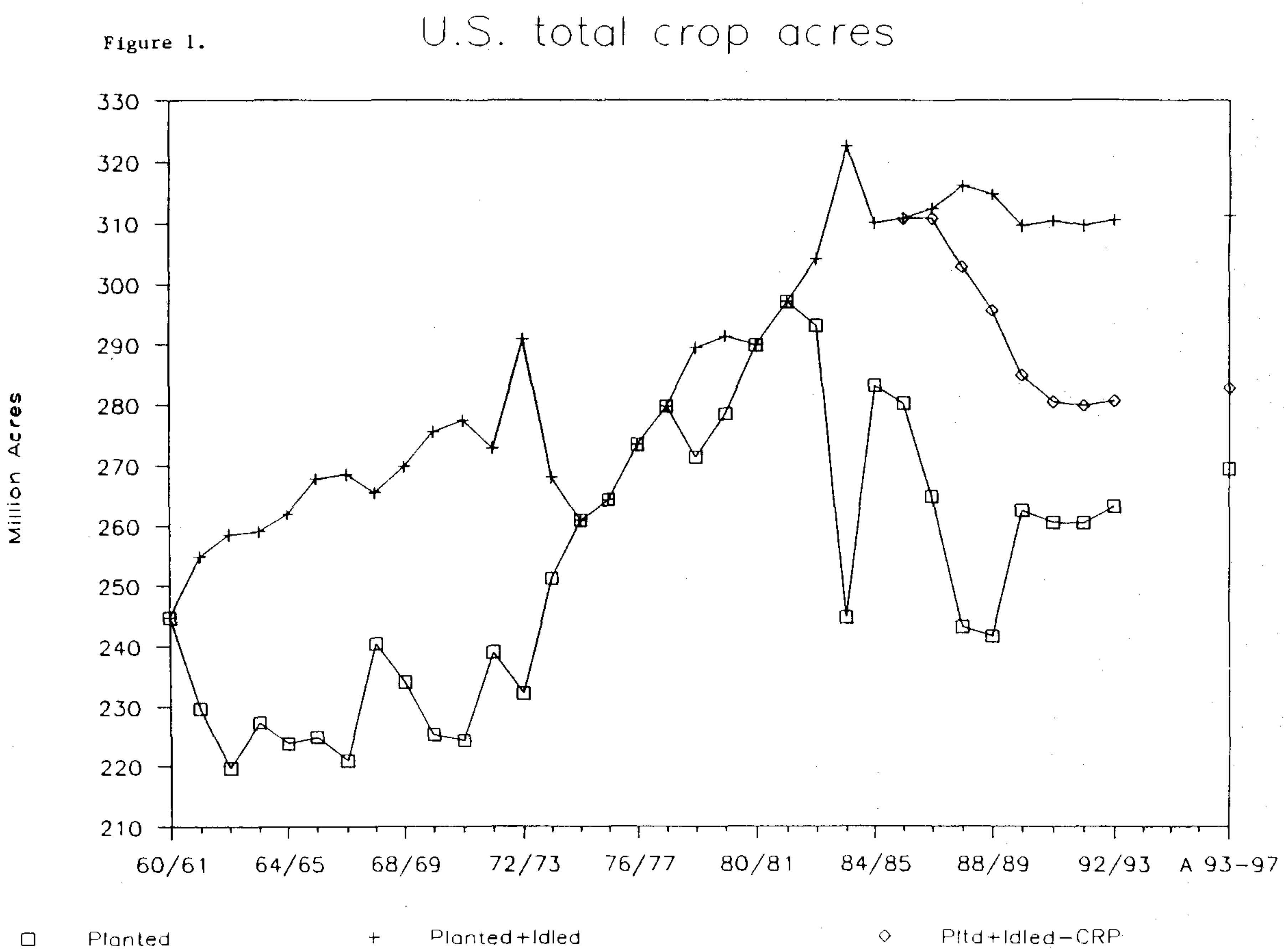
Since the FSA85, a number of developments have occurred that suggest even closer attention to trade-offs between agricultural and chemical policy: among them, state environmental legislation, standard setting by EPA, and prospects for the 1990 Farm Bill. First, residuals of agricultural chemicals used in crop production have been found in groundwater and surface water at levels suggesting health and environmental risk (Nielsen and Lee 1987). This and related information on food safety, applicator risk, and other negative externalities from chemical use have directed attention to new alternatives for regulating chemicals and chemical loading in the agricultural/environmental system. Also, states have become more heavily involved in the regulation of agricultural chemicals (Batie and Diebel 1989; Wise and Johnson 1989). Recent bills for Iowa and California are examples of these initiatives. A clear implication is increased attention by the public to effects of current agricultural practices on the environment (Batie 1986). At the same time, changes in market conditions and existing policy frameworks have reduced the region within which public decision makers are able to balance agricultural and environmental policy.

The situation as work begins on the 1990 Farm Bill differs in several respects from the one that conditioned the environmental/agricultural legislative dialogue in the FSA85. Generally, these differences will be reflected in higher market prices for agriculture, lower government outlays, lower participation in commodity programs, fewer idled acres through farmer participation in commodity programs involving supply control, and more public concern for agricultural-related environmental problems. Also, by 1990, 40 million acres of highly erodible land will be included in the conservation reserve. The implication is that there will be fewer opportunities for easy win-win interventions in agricultural/ chemical policy. The coordination of agriculture and chemical policies necessary to achieve mutually desirable policy outcomes will require added sophistication, information, and management skill on the part of producers and policymakers.

The agricultural supply and demand situation determining potential trade-offs between agricultural and chemical policies is suggested by Figures 1 and 2. In Figure 1, planted acreage for major program crops covered by the FSA85 is plotted historically, along with conservation reserve acreage, and annual idled acreage. The figure also includes projections through 1997, made by assuming economic conditions worldwide will remain generally similar to those experienced in 1988. An additional set of assumptions underlying the projections is that the 1990 Farm Bill will essentially continue the provisions of the FSA85 (e.g., frozen target prices, acreage reduction measures, voluntary participation in commodity programs) and that policies of major competitors in international markets will remain similar to those of 1988.

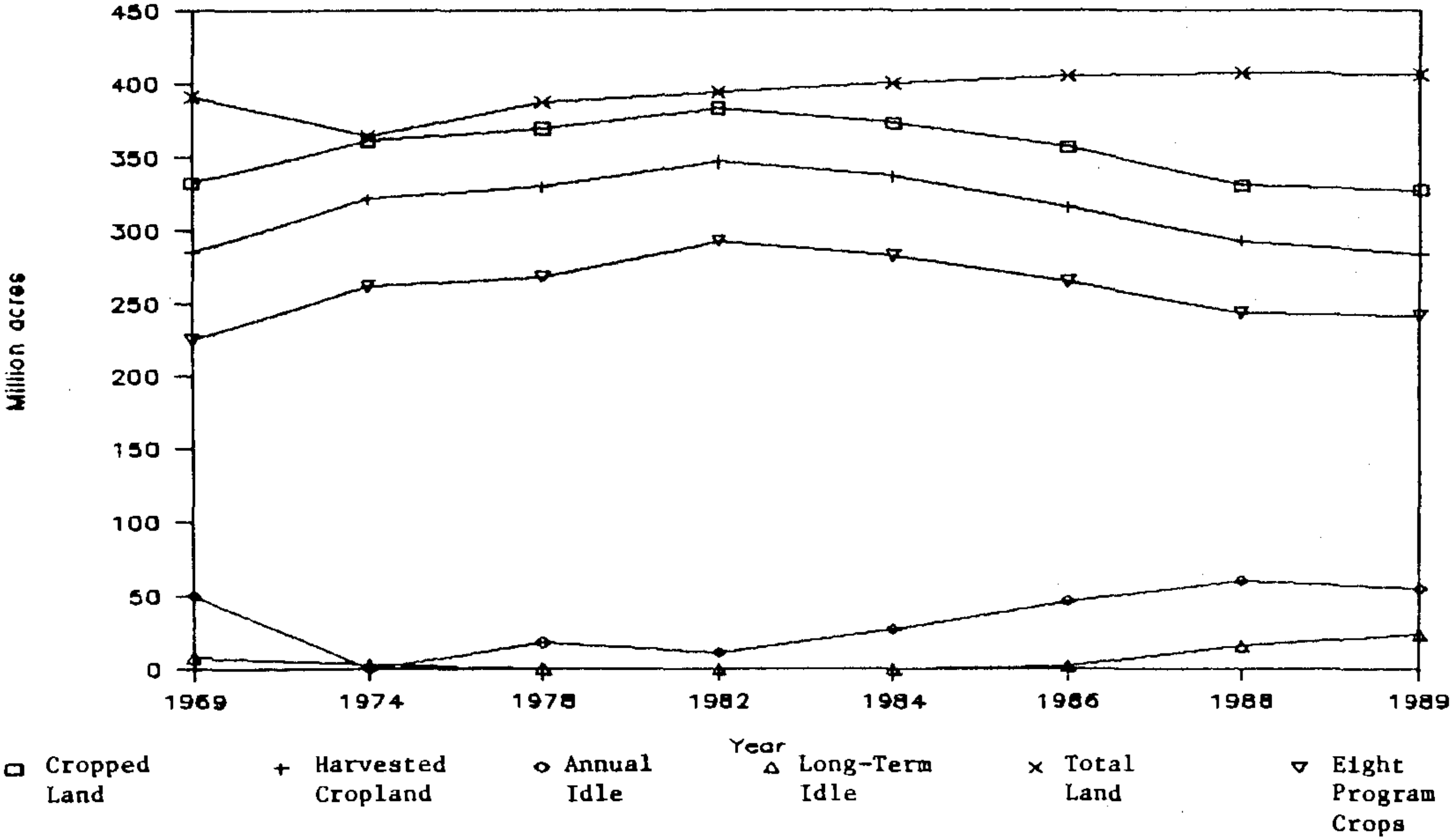
Figure 1 shows that even in the near term, annual idled acreage will be considerably smaller than in the immediate past, especially since the initiation of the FSA85. These numbers of idled acres, of course, involve only program crops. Also, the projections for planted and idled acres implicitly incorporate assumptions about technical change. These qualifications aside, a situation is suggested in which market prices will be closer to target prices, participation in commodity programs will be lower, program-idled annual acreage will be lower, and in general, the distorting impacts of government commodity policy will be reduced for domestic and international markets.

Figure 1.



Source: FAPRI (1989).

Figure 2. Cropland use in the United States



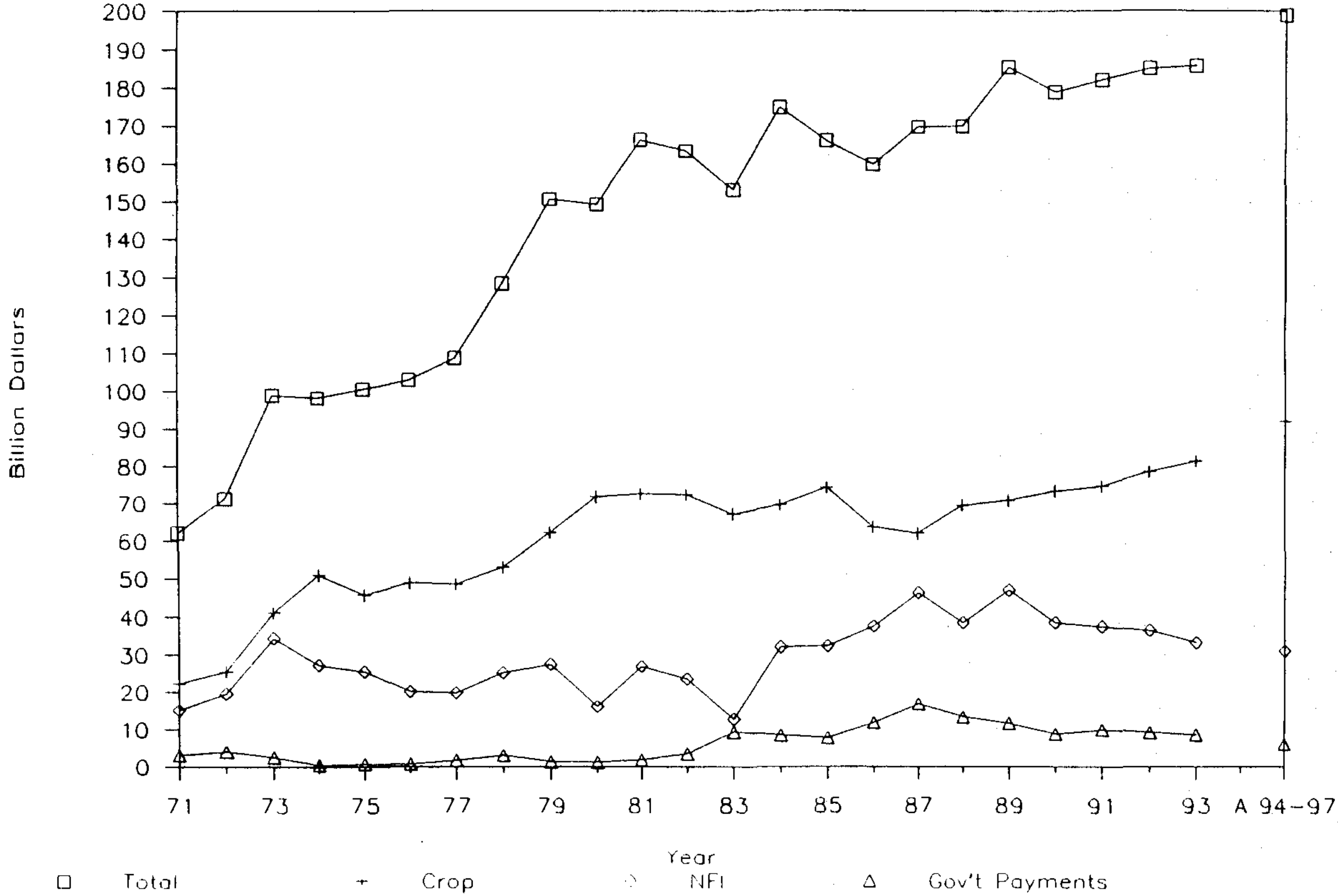
Source: U.S. Department of Agriculture (1988).

Figure 2 plots acreage idled in government programs (annual and long term), acreage harvested, acreage used for crops, and total acreage used and idled. Note that for the historical period shown, which spans a wide range of demand and supply conditions, the total amount of cropland has risen only slightly; while the proportion of idled acreage tied up in the long-term government reserve has grown. There is, in effect, a fairly tight cropland base in the United States. Added restrictions could increase costs of agricultural production. As Dvoskin (1988) noted, past subsidies may have resulted in land use above the efficient level. Another study (Atwood et al. 1989) has found that a reduction of the land use distortions associated with current programs would have greater environmental benefits than several of the polices currently being considered.

Commodity policies are motivated primarily by concerns for maintenance and stabilization of agricultural income. From Figure 3, gross farm receipts are expected to increase from current levels modestly in the near term. Although livestock demand is relatively flat, market prices for crops are increasing (causing reductions in government cost), leaving gross receipts relatively constant. However, net farm income is projected to decrease, largely on the basis of inflation-driven input cost increases and flat gross receipts. And, government costs are decreasing because of lower participation rates in commodity programs and higher commodity prices (resulting in lower deficiency payments).

Falling net farm income in the out-periods will make it difficult for agricultural interest groups to accept chemical policies that significantly

Figure 3. Total farm receipts and net farm income



Source: FAPRI (1989).

increase costs of agricultural production. These indicators of the supply-demand condition for agriculture describe in part a more constrained situation for chemical policy. Still, the EPA is likely to continue reviewing registration for major insecticides and herbicides, and to proceed with the establishment of water quality standards. State-level policies will tax and restrict the use of agricultural chemicals. Increased concerns about concentrations of nitrates in ground- and surface water will stimulate federal and state action. And, there will be significant pressure by environmentalists for chemical and water quality titles in the 1990 Farm Bill (Benbrook 1988).

In short, the agriculture and environmental situation as we enter the 1990s suggests more difficult decisions on trade-offs between agricultural and chemical policy. Commodity management policies will idle fewer acres, giving less room for complementarities in control of chemical loading and risk and agricultural income.

Selected Examples of Policy Trade-Offs

The following examples illustrate trade-offs between agricultural and chemical policy and are based on research undertaken during the past year by CARD. Of course, other research has contributed importantly to the empirical information available in this area. The examples included were selected primarily on the basis of familiarity with the procedures used and the results.

In reviewing the outcomes of the policy exercises, the emphasis is on results. Detailed discussions of the analytical models, the policy specifics, and other features of the analysis are contained in the referenced reports/publications. Brief background information is provided here in the material preceding the empirical results for each policy evaluation, in which the policy alternative is outlined and the baseline against which the policy outcome is compared is discussed. Also, the analytical system is identified and the introduction of the policy alternative of interest is reviewed. In many cases, these latter features for policy analysis exercises are keys to the results and their interpretation.

Conservation Compliance

The FSA85 included conservation compliance for participants in agricultural commodity programs. This stipulates that farmers participating in the commodity programs must be in compliance with conservation provisions by the early 1990s. Since the development of the legislation, conservation compliance has been specialized to states (alternative conservation systems published in technical guidelines). Generally, conservation compliance implies adjustments in cultivation practices and rotations, as well as potential shifts in regional production patterns. Also, in light of existing production technologies, conservation compliance may have important implications for chemical use.

Analysis. The analysis of conservation compliance was conducted with the CARD/ARIMS model (Atwood et al. 1989). The model was calibrated for 1990 using exogenous national and export demands estimated from CARD/FAPRI projections (FAPRI 1988). It must be noted that this analysis did not include consideration of the impacts of the 1988 drought. The ARIMS model uses a cost minimization criteria and does not explicitly incorporate commodity program participation rates. Thus, for the analysis, conservation compliance was assumed mandatory.

The comparison of the conservation compliance options was to a 1990 baseline. Yields, land available for cropping, and demand (domestic and export) were at levels predicted for 1990. Choices of alternative crop rotations, tillage methods, conservation practices, and livestock production practices, are modeled by ARIMS, by region, and determined endogenously. Key external conditioning factors used in the analysis are summarized in Table 1. A 45-million-acre conservation reserve was assumed for all policy scenarios.

The ARIMS model also includes regional flexibility constraints that reflect acreage bases for major program commodities, irrigation, and conservation structures. The policy analysis was based on a comparison of long-run equilibria for the baseline and different conservation compliance limits of 5 and 10 tons of allowable soil loss per acre, per year (1T and 2T, respectively). No attempt was made to describe the path from the current situation to the outcomes suggested by the solution of the model.

Results. Results of the analysis are summarized in Table 2 (Atwood et al. 1989). These results are organized by erosion, land use, total production cost, variable input cost, tillage practice, conservation

Table 1. Key external or conditioning factors for national model LP evaluations of conservation compliance scenarios

External Variable	Final Demand[a,b] (1000 units)	Yield Increase[c,d] (Percent/Yr)
Wheat	2,343,000 bu	2.28
Soybeans	1,940,761 bu	2.65
Corn	7,943,000 bu	1.89
Corn silage	--	1.89
Barley	543,000 bu	1.89
Oats	405,000 bu	1.89
Peanuts	46,050 bu	--
Sorghum	805,000 bu	1.89
Sorghum silage	--	1.89
Beef	446,700 cwt	--
Pork	239,800 cwt	--
Cotton	15,210 bales	1.01
Hay	--	1.02

[a]Sum of domestic demand, feed demand, and exports.

[b]Taken from "Proposed Program for CARD/FAPRI Outlook and Policy Review."

[c]Average percent per year for 1982-1990 period. Calibrated for most probably yield from 1985 Resources Conservation Act.

[d]Taken from The Second RCA Appraisal. Soil, Water, and Related Resources on Nonfederal Land in the United States. Analysis of Condition and Trends. (USDA 1987).

Table 2. National estimates for impacts of conservation compliance alternatives

		Erosion Limits (tons/ac.)[b]	
	Baseline[a]	10	5
		(percent difference from base)	
Erosion			
Sheet + Rill (ton/ac.)	3.50	-31.9	-43.9
Wind (ton/ac.)	3.80	-33.7	-46.2
Per Ac. Total (ton/ac.)	7.40	-32.8	-45.1
Reg. Total (mil. ton)	2,141.90	-32.4	-44.9
Land Use			
Cropped land (mil. ac.)	318.10	0.5	0.3
corn	69.70	0.0	-1.5
wheat	55.90	1.8	-1.4
soybeans	49.00	-0.9	1.8
cotton	11.70	-4.0	-7.2
nonlegume hay	34.66	-2.4	1.1
Total Prod. Cost (mil. $)	56,228.00	2.2	3.9
Crop cots (mil. $)	34,267.00	3.7	6.5
Livestock costs (mil. $)	21,960.00	0.0	0.0
Transportation (mil. $)	3,871.00	-1.9	0.3
Variable Inputs			
Nitrogen use (1,000 tons)	8,873.00	0.2	5.6
Pesticide cost (mil. $)	3,769.00	6.9	11.7
Tillage Practices			
Fall plow (1,000 ac.)	51,068.00	0.6	-19.2
Spring plow (1,000 ac.)	125,791.00	0.2	7.2
Cons. Tillage (1,000 ac.)	95,436.00	1.4	2.1
0-Tillage (1,000 ac.)	17,735.00	-1.2	-1.9
Conservation Practices			
Straight row (1,000 ac.)	257,084.00	-11.3	-21.0
Contour row (1,000 ac.)	4,439.00	187.2	378.3
Strip cropping (1,000 ac.)	1,304.00	1,800.0	3,043.3
Terracing (1,000 ac.)	27,303.00	-4.3	-5.9

SOURCE: Agricultural Resources Interregional Modeling System (ARIMS), CARD.

[a]Baseline refers to ARIMS projected 1990 scenario with a 45-million-acre CR (baseline), no limits on allowable soil loss, and FAPRI (1988) demands.

[b]The 10- and 5-ton erosion limit refer to ARIMS projected 1990 baseline comparison and annual limits on per acre soil loss for conservation compliance.

practice. For the present discussion, the emphasis is on erosion levels, chemical and fertilizer costs, and production costs.

Fertilizer expenditures increased nationally with imposition of both conservation compliance standards. Nitrogen fertilizer use increased by 5.6 percent for the 1T conservation compliance standard. Pesticide expenditures increased 6.9 and 11.7 percent above the baseline for the 2T and 1T standards, respectively. Some of the estimated increase in pesticide use resulted from expanded cropped acres, but most was associated with a shift to conservation tillage. The increase in nitrogen use was related to the cultivation of lower-quality land, which required higher nitrogen inputs. Also, the kinds of crop rotations used to meet conservation compliance leave more organically produced nitrogen in the system that is unused by row crops.

Total erosion was reduced by 45 and 32 percent for the 1T and 2T standards, respectively. Associated increases in total production costs were 3.9 and 2.2 percent. Total land use increased 0.3 and 0.5 percent above the baseline for the 1T and 2T standards. For most regions, the erosive impact of the higher levels of land use was more than off-set by tillage practices that reduced per acre erosion levels. Because final demands were fixed, the only possible changes in commodity production levels involved intermediate inputs and a few cases of overproduction that resulted when specific crop rotations were required to meet erosion abatement standards.

Of course, qualifications are in order for analyses with such highly restrictive models. First, it is emphasized that the conservation compliance standards were mandatory and that current policies based on individual state technical guidelines were not specifically evaluated. But, from a review of these guidelines, the 2T criteria for minimizing soil loss appears to be a reasonable approximation of how the program currently is being implemented. Second, production cost increase estimates probably are high. Simply put, farm operators are smarter and more resourceful than can be captured by the rigid budgets in ARIMS. Third, soil loss restrictions were estimated using the universal soil loss equation (USLE) (Wischmeier and Smith 1978), which includes a significant level of error for both water-induced erosion and wind erosion (Smith and English 1982). However, the results demonstrate that even a relatively modest mandatory restriction on soil loss--2T, for example--can result in major reductions in erosion rates and relatively small increases in production costs and costs overall. Tighter standards, such as the 1T level, increase costs more than proportionately.

Nitrogen Tax

Nitrate levels in potable water sources that imply risk to human health have been widely detected in the U.S. (Nielsen and Lee 1987). One alternative for limiting the use of nitrogen is a tax (Swanson 1982). To date, such taxes have been relatively small (Iowa House of Representatives 1987). And, important questions remain on the likely national impacts of taxes on nitrogen and other chemicals on input use, water quality, agricultural income, crop production patterns, and other indicators of environmental and agricultural performance. Results of this exercise were intended to provide information for assessing possible consequences of a national nitrogen tax.

Analysis. The analysis was of a five-cent nitrogen tax. The analytical system used was ARIMS. The ARIMS model for the nitrogen tax exercise was conditioned using the same external factors as for the conservation compliance analysis. Also, to incorporate the effects of the nitrogen tax, input use coefficients for each productive activity in the model were adjusted to reflect the increased relative cost of nitrogen. These input levels were adjusted using a simple yield/fertilizer response function (English, Alt, and Heady 1982). In the ARIMS model, nitrogen, phosphorus, and potassium are applied in fixed proportions, so the adjustments in nitrogen implied similar adjustments in other fertilizer inputs. As for the conservation compliance evaluation, only the regional crop acreage flexibility constraints incorporated in ARIMS reflected government commodity program parameters.

Modeling the effects of the tax with ARIMS required two steps. First, under the assumption of profit maximization, each alternative production activity in ARIMS had fertilizer/yield coefficients adjusted to reflect the relative price changes associated with the tax. Secondly, under the assumption of movement to a new long-run competitive equilibrium, optimization procedures were used to determine national production, feeding, transportation, and consumption levels consistent with the tax. Changes in reported aggregate fertilizer from the ARIMS solution may arise from three sources: (1) changes in fertilizer/yield relationships on an individual crop acre basis, (2) changes in crop rotations to take advantage of legume fixed nitrogen carryover and changes in manure production and applications, and (3) changes in high-nitrogen-demanding cropping patterns, with accompanying changes in crop utilization patterns.

Results. The five-cent nitrogen tax represented an approximate 20 percent increase in the nitrogen price as imposed in the ARIMS budgets; the baseline nitrogen price varied by region but was between 22.5 and 27.5 cents per pound. In general, as a result of the optimization calculations (external to ARIMS) using the fertilizer crop yield response functions, nitrogen use was reduced by approximately 5 percent and yields changed 1-2 percent. Results of the analysis are summarized in Tables 3 and 4. In addition to these results, the ARIMS solution provides information on impacts for non-nutrient input use, soil erosion, tillage practices and crop rotations, livestock production, and producer and consumer welfare. Tables 3 and 4 address only fertilizer application and production costs compared to the baseline.

At the national level, per acre nitrogen use declined 10 percent. Regional changes were between 4 and 13 percent, depending on the region (Table 3). Since N, P, and K are used in fixed proportions, similar adjustments were observed for other chemical inputs. These reductions in applied nitrogen were offset by about one-half by legume-produced nitrogen. From this analysis, the increase in legume production was 2.5 percent nationally. This would imply that approximately one-half of the substituted legume-based nitrogen was already residing within the system as a result of crop rotations. Thus, in total, nitrogen used by crops was

Table 3. Impact of nitrogen tax on nutrient applications (percentage change from baseline)

	Nitrogen		Phosphorous		Potassium	
	Total	Per Acre	Total	Per Acre	Total	Per Acre
Northeast	5.8	-3.7	11.8	1.7	11.6	1.5
Appalachia	-7.9	-7.4	-3.8	-3.3	-4.9	-4.4
Southeast	-4.3	-4.0	-4.0	-3.8	-3.1	-2.8
Delta	-7.2	-8.8	-5.4	-7.0	-5.4	-7.0
Corn Belt	-9.8	-10.8	-4.2	-5.2	-4.5	-5.5
Lake States	-8.4	-8.4	-3.6	-3.6	-6.7	-6.7
Northern Plains	-13.2	-13.2	-11.1	-11.1	-11.8	-11.8
Southern Plains	-11.9	-11.9	-11.1	-11.0	-9.9	-9.8
Mountains	-9.0	-9.3	-5.0	-5.3	-5.9	-6.2
Pacific	-5.4	-6.3	-2.2	-3.0	-2.2	-3.1
National	-9.4	-10.1	-3.4	-4.2	-5.9	-6.6
National base[a]	8,040.0	50.0	4,184.0	26.0	2,829.0	18.0

SOURCE: Atwood, Jay Dee, and S. R. Johnson. 1990. "The Potential for 'LISA'-Type Nitrogen Use Adjustments in Mainstream U.S. Agriculture." CARD Working Paper 90-WP 49 (also forthcoming in Journal for Soil and Water Conservation). Center for Agricultural and Rural Development, Iowa State University, Ames.

[a]Baseline quantities are thousands of tons.

Table 4. Impact of nitrogen tax on output price index (percentage change from baseline)

	Crops	Livestock
Northeast	13.1	0.8
Appalachia	-0.1	0.6
Southeast	-0.5	-0.2
Delta	2.1	2.1
Corn Belt	0.9	1.9
Lake States	0.2	4.0
Northern Plains	0.0	0.2
Southern Plains	1.3	5.1
Mountains	0.9	0.0
Pacific	0.5	0.4
National	1.3	0.0

SOURCE: Atwood, Jay Dee, and S. R. Johnson. 1990. "The Potential for 'LISA'-Type Nitrogen Use Adjustments in Mainstream U.S. Agriculture." CARD Working Paper 90-WP 49 (also forthcoming in Journal for Soil and Water Conservation). Center for Agricultural and Rural Development, Iowa State University, Ames.

down about 5 percent, and excess nitrogen in the system was reduced by about one-half as a result of tax-induced changes in rotation choices.

Major differences were observed by production region, with the largest reductions in total in the Northern and Southern Plains. Generally, these were due to changes in cropping practices and--in the Southern Plains--the use of rotations that involve increased cropping intensity. For other inputs, the choices implied by the tax resulted in production increases (Atwood and Johnson 1989). For most regions, pesticide application rates increased, as did machinery and labor inputs. These resulted from shifts to more intensive cropping.

Output price indices are constructed for crops and livestock under the assumption that price equals marginal cost (at the fixed demand levels); baseline quantity weights also were assumed. Results for these price indices, nationally and by region, are provided in Table 4. They are expressed as percentage changes from the baseline and are designed to provide an indication of the impact of the nitrogen tax on production costs. At the national level, there was only a 1.3 percent increase in the crop price index and no change in the livestock price index. Most regional impacts were relatively small, except for the 13.1 percent crop price increase in the Northeast and increases of livestock prices by 4.0 and 5.1 percent in the Lake States and Southern Plains, respectively.

Hence, although there were regional implications of the nitrogen tax, the overall national impact on crop production costs and implied changes in market prices of agricultural commodities associated with the five-cent nitrogen tax was estimated to be relatively small. Possibly the most interesting result from the analysis for the nitrogen tax involved the fact that given the model structure, the increase in nitrogen price resulted in more efficient use of organic nitrogen in crop production. This, together with the lower use of nonorganic nitrogen, would imply a reduced loading of nitrates in ground- and surface water.

Targeting the Conservation Reserve

The conservation reserve authorized by the FSA85 encourages farmers to idle highly erodible cropland and other land that meets eligibility criteria, and to convert it to permanent vegetative cover. Under current provisions, two criteria designate cropland as highly erodible: an erodibility index equal to or greater than eight for wind or water erosion, or an erosion rate greater than that recommended by SCS field technical standards based on soil loss tolerance. For the erodibility criteria, at least two-thirds of a field must be considered highly erodible and must have been cropped between 1981 and 1985 for eligibility in the conservation reserve (USDA 1987).

The conservation reserve analysis reported illustrates the possibility of enhancing environmental benefits by targeting (Frohberg et al. 1989). The objective was to evaluate targeting a portion of the conservation reserve to land adjacent to water bodies, flowing streams, and river waterways. These lands are termed buffer or filter strips. Within the conservation reserve program, significant potential exists for enhanced environmental benefits beyond erosion abatement by changing targeting criteria. The rationale is that buffer strip lands removed from crop production will act to limit waterway sedimentation and filter upland erosion material with associated pollutants from runoff before the runoff reaches waterway channels. Buffer strips of 100 feet in width were assumed for the analysis.

Analysis. The analytical system used for evaluation of the buffer strip targeting was the Comprehensive Economic Environmental Policy Evaluation System (CEEPES), developed by CARD under contract with EPA. Essentially, CEEPES is a suite of process and economic models that includes components for agricultural decisions, biogeophysics, health risk, and policy interaction (Johnson et al. 1989). For the targeting, a reduced version of CEEPES was applied, emphasizing the agricultural decision component. Specifically, national market-level models and state-level profit maximization models for the upper Mississippi River basin were used.

The baseline for the multimarket commodity models was from 1988 prior to the drought (FAPRI 1988). The results reported are for a targeting of five million acres of the 45-million-acre conservation reserve to buffer strips. The analysis required detailed calculations of land available for buffer strips. Because there are essentially no national-level data available on acres of land adjacent to water bodies, flowing streams, and river waterways, these data had to be synthesized from a number of sources (Frohberg et al. 1989). Also, analytical methods were necessary to estimate the amount of land eligible for buffer strips already in the conservation reserve or in lands under public control. Needless to say, these estimation methods were not without fault. But, the exercise highlighted the scarcity of information available for environmental targeting of the conservation reserve.

Results. Results of the exercise evaluating targeting of the conservation reserve are provided in Tables 5 and 6. In Table 5, market price implications of the targeting are identified for major program crops and projected through 1991/92. The important figures are the changes from the base. Estimation of these differences is more reliable than the estimation of the levels. Generally speaking, five million of the 45-million-acre reserve could be targeted to buffer strips without significantly affecting agricultural commodity prices. The major change observed, albeit small, involved cotton and small grains. This is because the targeting shifted conservation reserve enrollment to the Corn Belt from the plains and southern states. With commodity program provisions remaining the same between the targeted alternative and the baseline, increased acreages for these crops were estimated, resulting in slight reductions in prices.

Results not shown indicated that the government costs associated with the targeting were minimal under the market situation in 1988. Shifting the conservation reserve to the Midwest increased rental rates but in turn decreased deficiency payments, which were higher for coarse grains.

Implications for the Midwest were evaluated by linking profit maximizing production area models to the 1988 prices and participation rates generated from the multimarket commodity model (summarized in

Table 5. Market prices for the baseline (45/0) and a targeting alternative, 5 million targeted acres in a 45-million-acre CRP (45/5)

	1987/88	1988/89	1989/90	1990/91	1991/92	1988-91 Average	Change from Base	Percent Change
	(Dollars per Bushel)							
Wheat								
45/0	2.56	2.86	3.00	3.05	3.09	3.00		
45/5	2.56	2.86	3.00	3.05	3.09	3.00	0.00	0.0
Corn								
45/0	1.71	1.91	2.00	2.05	2.11	2.02		
45/5	1.71	1.92	2.01	2.06	2.13	2.03	0.01	0.6
Sorghum								
45/0	1.60	1.74	1.91	2.04	2.03	1.93		
45/5	1.60	1.74	1.91	2.04	2.03	1.93	0.00	0.0
Oats								
45/0	1.65	1.46	1.52	1.60	1.65	1.56		
45/5	1.65	1.47	1.52	1.60	1.66	1.56	0.00	0.3
Cotton[a]								
45/0	0.630	0.602	0.584	0.593	0.606	0.596		
45/5	0.628	0.597	0.575	0.582	0.594	0.587	0.009	-1.6
Rice[b]								
45/0	6.96	5.91	6.18	6.49	6.59	6.29		
45/5	6.96	5.91	6.18	6.49	6.59	6.29	0.00	0.0
Soybeans								
45/0	5.63	6.14	5.23	5.24	5.79	5.60		
45/5	5.63	6.15	5.25	5.26	5.80	5.62	0.01	0.3

SOURCE: "National and Regional Impacts of Targeting the Conservation Reserve." CARD Staff Report 89-SR 39, Center for Agricultural and Rural Development, Iowa State University, Ames.

[a]Dollars per pound.

[b]Dollars per hundredweight.

Table 6. Comparison of the 45/5 alternative to the baseline (45/0), by production area

	PA 39	PA 40	PA 41	PA 42	PA 43
			(percent)		
Net income, crops	-0.2	-0.3	-0.5	0.2	-0.1
Production					
Corn (bu.)	1.0	-0.2	0.4	-1.8	-2.0
Soybeans (bu.)	-0.1	-0.3	0.4	-1.0	-2.2
Land use, corn	0.9	0.0	0.6	-2.0	-4.2
Soybeans	-0.2	0.1	0.5	-1.4	-4.2
CRP	-2.5	1.2	-3.4	20.9	10.0
CRP % of total land base	-2.4	1.1	-3.4	21.0	11.9
Tillage					
Conventional	0.5	0.0	0.1	-0.3	0.6
Reduced till	0.0	-1.0	1.6	0.0	1.6
No till	0.0	0.0	0.0	-86.5	0.0
Pesticide use					
Alachlor	1.0	-0.3	0.3	-0.9	-1.9
Atrazine	1.0	-0.1	0.7	-1.9	-1.4
Land rental values					
Soil class one	-0.3	0.4	-1.8	1.8	0.0
Soil class two	-0.2	0.1	-1.9	6.9	0.0
CRP shadow price	-0.5	-0.3	-0.6	4.5	-0.2

SOURCE: Frohberg et al. (1989).

Note: PA 39 is in Minnesota; PA 40 is in Wisconsin; PA 41 is in Iowa; PA 42 is central Illinois; PA 43 is southern Illinois

Assumptions:

	Corn	Wheat	Soy	Hay
Price chg. from base	+0.5%	0%	+0.5%	0%
Deficiency pmt.	$0.69	$0.95		
Set-aside rqmt.	20%	10%		

Table 5). These results are summarized in Table 6. These area-level models include highly specialized production activities identifying tillage practices, pesticide use, and so on. Results generated indicate that changes by production area were relatively small (Table 6). That is, net incomes from crops were relatively similar with and without the targeting of the conservation reserve. The major differences in input use related to the increased conservation reserve land that was idled as a result of targeting.

For purposes of analysis, five production areas were identified along the upper Mississippi River basin (Fig. 4). Within that area, the targeting moved conservation reserve land from production areas 39 and 41 (Minnesota and Iowa) to PA 40, 42, and 43 (Wisconsin, Central Illinois and Southern Illinois); this movement was related to the value of base acres in production. The land rental values, calculated using the shadow prices to the programming analysis, indicate that higher conservation reserve rental rates would be required in production area 42 as a result of the targeting. Generally, the results suggest that the targeting of conservation could occur with relatively minor adjustments to the agricultural sector, although the potential changes in crop production levels regionally imply significant local impacts.

Corn Rootworm Insecticide Ban

Heavy use of corn rootworm insecticides has evolved in the United States (CARD 1988). In Iowa for example, about 35 percent of the planted acres are treated with corn rootworm insecticides (Table 7). And, the

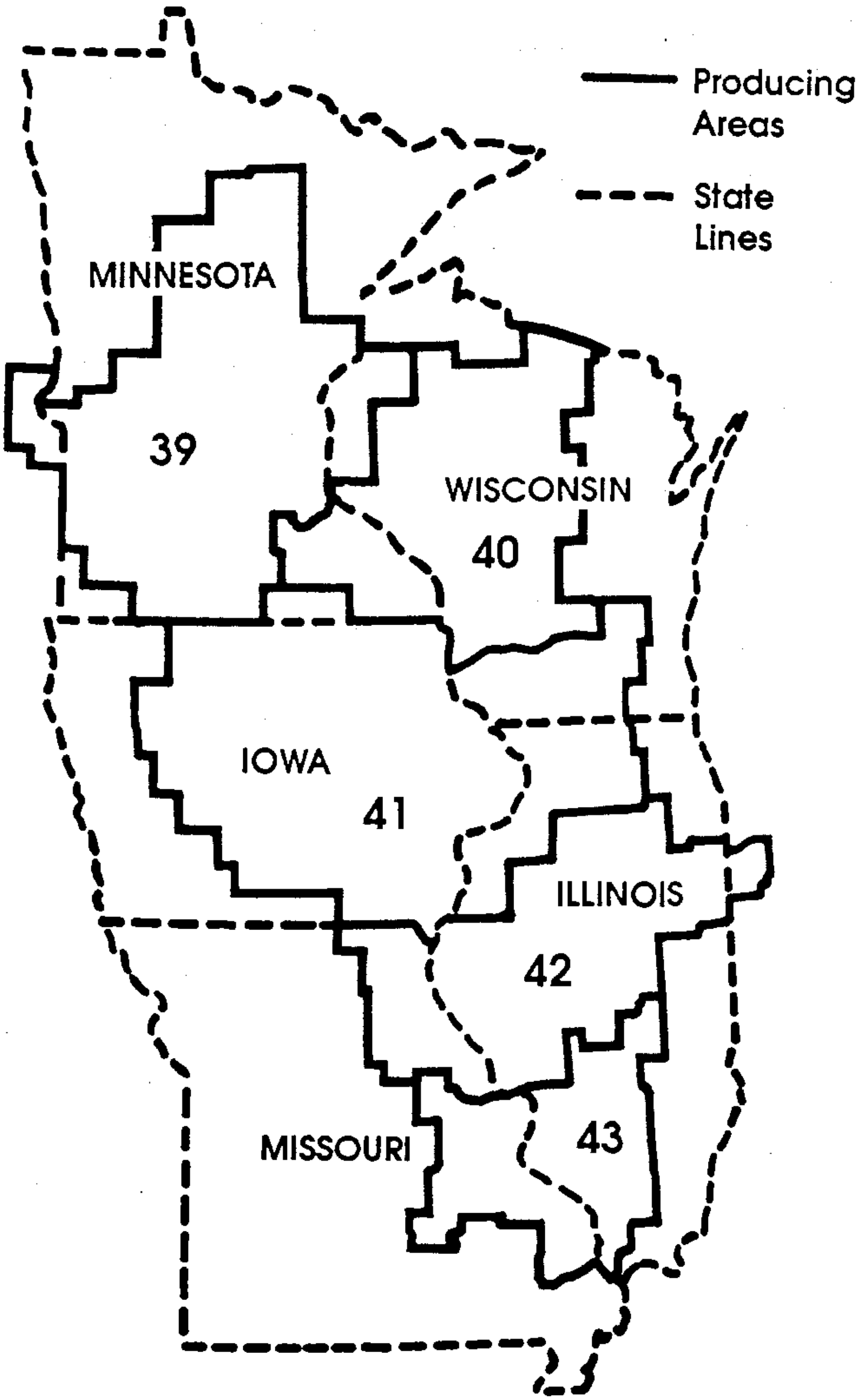


Figure 4. The five producing areas of the upper Mississippi basin area

Table 7. Acres of Iowa corn treated with soil insecticides for corn rootworm larval control, 1985

Insecticide Use	Acres Corn Following Corn	Acres Corn Following Soybeans	Acres Corn Following Other Crops	Total Acres Treated
Broot	51,000	0	0	51,000
Counter	1,452,000	152,000	38,000	1,642,000
Dyfonate	831,000	75,000	26,000	932,000
Furadan	366,000	5,000	8,000	379,000
Lorsban	1,032,000	233,000	57,000	1,322,000
Mocap	18,000	0	0	18,000
Thimet	606,000	30,000	20,000	656,000
Other	3,000	0	0	3,000
Total treated	4,359,000	495,000	149,000	5,003,000
Total planted	5,560,000	7,367,000	973,000	13,900,000
Percent acres treated	78%	6.7%	15.3%	35.99%

SOURCE: Table 21, "Pesticide Used in Iowa Crop Production in 1985." ISU PM 1288, Cooperative Extension Service, January 1987.

active chemicals used in treating for corn rootworms are substantial (Table 8). The policy simulated was for a ban of corn rootworm insecticides. Interest in this policy was stimulated by information on environmental loading of agricultural chemicals. However, the half-lives of the active ingredients in corn rootworm insecticides are relatively short, so the implied environmental enhancement associated with a ban could be relatively low.

Analysis. The CEEPES system described for the policy exercise on targeting land for the conservation reserve was applied for this analysis. Calibration of CEEPES was identical to that used for the buffer strip evaluation. In addition to the agricultural decision component, the biogeophysical component of CEEPES was exercised for this analysis. In particular, plant growth models and soil root zone models were applied to estimate impacts of reduced weed control on yields and the fate or transport of different corn rootworm chemicals.

Effects of the ban were evaluated using national commodity market models, production region models, and farm-level models. The farm-level and region-level models incorporated acreage bases and more of the specifics of the current agricultural commodity programs. At the farm level, the corn base acreage was a critical factor in determining the economic impact of the ban. The production region and farm-level models were used to evaluate economic values of base acres lost when producers decide not to grow corn at the levels required to maintain the corn base.

Table 8. Summary of corn rootworm insecticide use in Iowa, 1985

Insecticide	Acres Treated (000)	Percent Distribution	Pounds Active Ingredient	Percent Distribution
Broot 15GX	51	0.9	62,662	1.0
Counter 15G	1,642	29.8	2,048,395	32.8
Dyfonate 20G	900	16.3	1,122,433	18.0
Dyfonate 4EC	32	0.6	39,901	0.6
Furadan 15G	364	6.6	453,636	7.3
Furadan 4F	15	0.3	18,679	0.3
Lorsban 15G	1,282	23.3	1,598,804	25.6
Lorsban 4E	40	0.7	50,250	0.8
Mocap	18	0.3	22,537	0.4
Thimet 20G	656	11.9	819,001	13.1
Other	505[a]	9.2	---	---
Total	5,505	100	6,237,298	100

SOURCE: Table 23, "Pesticide Used in Iowa Crop Production in 1985." ISU PM 1288, Cooperative Extension Service, January 1987.

[a]Changed from 5,000 in original table to 505,000 here so that column adds to 5,505,000.

This decision would be in response to the likelihood of corn rootworm infestation of continuous corn rotations.

Results. Findings from the biogeophysical components of CEEPES indicated that surface water was at greater contemporary risk than groundwater from contamination through use of corn rootworm insecticides. Surface water contamination resulted from insecticide runoff and from tile discharge. Results of the analysis with the root zone models showed that carbofuran (furadan) and ethoprop (mocap) exhibited potential to leach into shallow aquifers. This was especially true for soils of coarse texture. Generally, those insecticides with longer half-lives and low soil absorptive properties were more likely to enter ground- and surface water. The root zone model analysis results indicate that a total ban would be unnecessary to eliminate the presence of compounds in groundwater. Targeting of areas with high potential leaching due to soil resource characteristics, along with restricting the use of selected insecticide compounds, could be sufficient for significantly reducing potential contamination by corn rootworm insecticides (Table 9).

An erosion productivity calculator was used for evaluating yield reductions caused by heavy rootworm infestations. Generally, the results showed that the yield responses to infestation were highly related to the rainfall pattern during the year. In wet years, modest infestations of rootworms had relatively small impacts, because the rainfall afforded an opportunity for regrowth of the corn root systems.

Table 9. Simulated yearly average concentrations of seven insecticides (parts per billion)

Soil and Insecticide	Volatilization						Nonvolatilization					
	Runoff (ppb)			Leaching (ppb)			Runoff (ppb)			Leaching (ppb)		
	Dry	Normal	Wet	Dry	Normal	Wet	Dry	Normal	Wet	Dry	Normal	Wet
Plainfield												
Terbufos	0.00	0.00	0.00	0.00	0.00	0.00	27.69	7.82	3.01	0.00	0.00	0.00
Carbofuran	149.53	18.40	11.46	1.03	41.55	29.57	340.92	49.94	22.85	1.64	70.27	51.20
Chlorphrifos	.01	0.00	0.00	0.00	0.00	0.00	6.27	3.28	2.80	0.00	0.00	0.00
Fonofos	0.00	0.00	0.00	0.00	0.00	0.00	76.79	31.22	19.35	0.00	0.00	0.00
Trimethacarb	11.41	2.18	1.08	0.00	0.00	0.00	162.56	68.76	41.19	0.00	0.00	0.00
Ethoprop	218.25	49.74	17.15	4.78	0.80	8.31	408.44	105.91	36.05	8.27	1.22	13.91
Phorate	0.00	0.00	0.00	0.00	0.00	0.00	8.72	1.59	0.84	0.00	0.00	0.00
Tama												
Terbufos	0.00	0.00	0.00	0.00	0.00	0.00	25.46	16.73	3.48	0.00	0.00	0.00
Carbofuran	190.07	70.31	14.65	0.52	0.03	0.93	440.14	173.43	30.76	0.98	0.06	1.74
Chlorpyrifos	0.02	0.01	0.00	0.00	0.00	0.00	5.63	4.97	2.84	0.00	0.00	0.00
Fonofos	0.00	0.00	0.00	0.00	0.00	0.00	68.82	54.45	20.44	0.00	0.00	0.00
Trimethacarb	11.09	5.71	1.26	0.00	0.00	0.00	145.89	113.20	43.85	0.00	0.00	0.00
Ethoprop	205.79	112.14	20.79	0.01	0.00	0.01	383.22	222.68	45.47	0.02	0.00	0.01
Phorate	0.00	0.00	0.00	0.00	0.00	0.00	8.57	4.32	0.97	0.00	0.00	0.00

SOURCE: Pesticide root zone model results. CARD 1988.

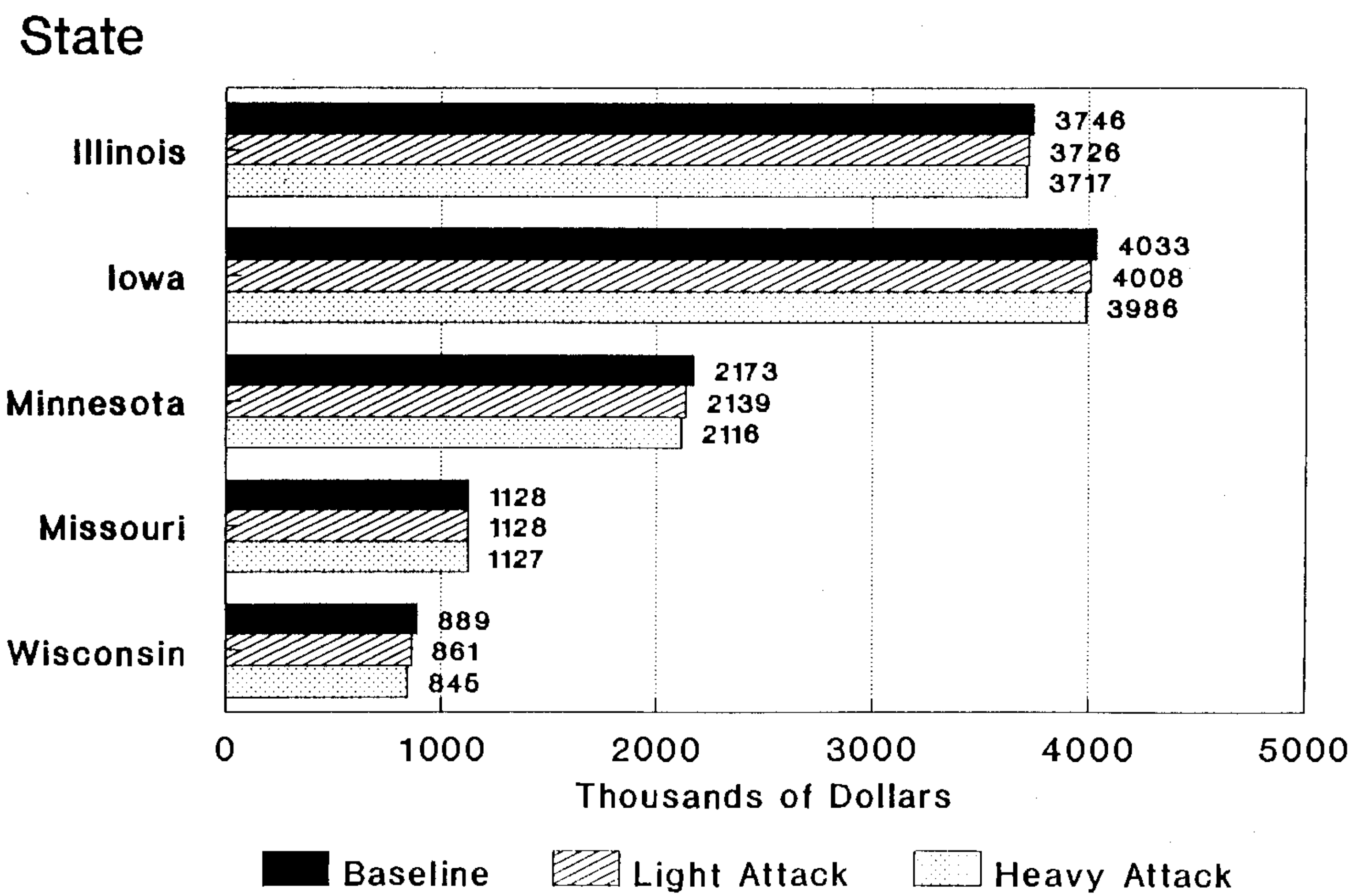
Note: Simulations involved three weather scenarios (dry, normal, wet) based on weather data for Kossuth County, Iowa, and two soils: Plainfield (coarse texture) and Tama (fine texture). Application rate = 1.12 kg/ha; plant uptake efficiency = 100%.

These results for yield impacts were incorporated in state-level, profit maximizing models. Generally, the results from the state-level models indicated that the economic impacts of the ban on corn rootworm insecticides would be relatively small. The most notable behavioral response was a shift away from rotations with corn following corn. Prior to the insecticide ban, more than 30 percent of the corn grown in the five-state upper Mississippi River basin area was planted to continuous corn. After the insecticide ban, this figure was reduced to 5.9 percent and 5.2 percent under heavy and light infestation assumptions, respectively. In the five-state area, total corn acreage was, however, reduced only by 1 to 2 percent depending on the corn rootworm infestation level assumed. Generally, the production adjustments were to move to corn and soybean rotations instead of rotations where corn followed corn.

The reductions in net farm income, shown in Figure 5, result from the use of lower-quality land and more extensive rotations. These income reductions were relatively low. Nitrogen application levels also declined as more legumes were added to rotations. There were significant reductions in the use of broadleaf and grass herbicides for corn production, but herbicides associated with soybean production increased.

The conclusion from the analysis was that if base acreage provisions for the commodity programs were more flexible and paired with limitations in the use of corn rootworm insecticides, the result would be minor changes in cropping patterns and in net farm income, along with significant reductions in the use of corn rootworm insecticides. Major economic impacts were for farms with very large corn bases relative to total

Figure 5. Net farm income by state



Source: CARD, 1988

acreage. The corn rootworm insecticide ban would force these farmers to move to corn/soybean rotations, loosing substantial corn acreage base. Base flexibility as a feature policy would leave these farmers in relatively similar economic positions and would significantly reduce applications of corn rootworm insecticides. This exercise suggested the importance of "packaging" environmentally motivated policies directed at agriculture with agriculture price and income stabilization policies. This packaging, if carefully designed, could result in significantly improved agricultural incomes/environmental trade-offs.

Observations

Results from four environmental/agricultural policy exercises provided useful insights. Generally, these analyses showed that environmentally motivated changes in agricultural production patterns and practices could be accommodated in U.S. agriculture with relatively modest increases in production costs. Also, regional adjustments associated with these policies appeared to be relatively minor. Setting aside the question of the responsibility for the increased costs, the results indicated considerable opportunity for bringing agricultural price and income stabilization policy mechanisms and environmental policy into closer harmony--especially for the agricultural supply/demand situation as reflected in 1988 prior to the drought.

The frailty of policies that tie environmental and agricultural instruments was highlighted by comparing the baseline prices and performance variables for agriculture from the selected evaluations to the current agricultural situation. Clearly, the outcomes for these tied policies are highly conditioned by the market situation for agriculture and, of course, the agricultural policy framework. The illustrative evaluations were all conducted in early 1988, prior to the drought. The high stocks of major program commodities on hand at that time suggested continuation of significant acreage reduction programs. Of course, the situation has changed significantly. However, for the 1989 baseline conditioned by the 1988 drought (FAPRI 1989), acreage reductions were lower and market prices were higher, and government costs of the agricultural programs were reduced. A reevaluation of the consequences of the environmentally motivated policies selected for inclusion in this discussion would be quite different under the current circumstances in domestic and world agricultural markets. In general, the policies could be accommodated, but there would be higher opportunity costs for farm income and increased changes in interregional production patterns.

The general conclusion from these policy exercises and observations thus is mixed. Opportunities exist and probably will continue to exist for improving coordination of agricultural and environmental/chemical policies. Generally, to facilitate improved harmonization, agricultural and chemical/environmental policies will require flexibility and the continual tuning of a fairly complex set of instruments. These adjustments in the policy instruments and the potential benefits from harmonization are highly dependent on forces outside the control of the policymakers--for example, weather.

The argument, then, is for flexible policies and a recognition that the settings of the instruments for policymaking will require adjustment as the factors conditioning agriculture and the environment change. Whether these types of policies are achievable in the current institutional setting is a subject for continued study and debate. The alternative is more blunt policy instruments, which implies more significant income and production impacts for the agricultural sector to achieve targeted environmental performance standards, and of course, more serious questions about the responsibility for the associated economic adjustments.

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